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PROSPECTS OF NUCLEAR POWER IN PAKISTAN

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PROSPECTS OF NUCLEAR POWER IN PAKISTAN

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Introduction

1. The standard of living of an average Pakistani is one of lowest in the world. One of the principal aims of the Government of Pakistan is to improve the standard of living of its people, through a series of a long term development plans. The Second Five Year Plan of Pakistan which started in the middle of 1960 is in the process of implementation. One of the short-comings of the Five Year Plans is that the period at disposal is short,-it does not give sufficient time to some of the projects to be completed during the plan period. In fact, the two Five Year Plans of Pakistan could be regarded as one Ten Year Plan. In view of the experiences gained from the Five Year Plans, it is often suggested that the next plan should be over a longer period, possibly of 20 to 25 years. It is in accordance with the principles of such long-term planning that attempts have been made in this paper to foresee the requirments of Pakistan in the field of power generation within the next forty years and also to examine the resources that are available or likely to be available during the period. It is during the analysis of the requirements of the country of the next forty years that nuclear power appears as an alternate and a highly competitive source of power generation compared to other sources presently employed.

2. The power situation obtaining in any country depends on a number of factors which vary from country to country, so that the analysis of the requirements of Pakistan will have to be made in the context of the situation prevailing in Pakistan.

Population of Pakistan in 2000 AD

3. Population of Pakistan in 1961 (1) was 93.8 million, consisting of 50.8 million in East Pakistan and 43.0 million in West Pakistan. The growth of population in West Pakistan during the period from 1951 to 1961 was 27.1% and that in East Pakistan during the same period was 20.9%, the average being 23.7%. During the period from 1901 to 1961 the annual growth of population in West Pakistan was 1.68% compound. It is found that between the period 1931 to 1961 the growth of population in West Pakistan was nearly 2.1% compound per annum. However, it is hoped that as more and more people get educated and as the Government's drive to popularise family planning succeeds, the growth of population in West Pakistan during the next forty years will not be more than 1.68% compound per annum, so that the population of West Pakistan by 2000 AD will be about 83.4 million. In East Pakistan the growth of population between the year 1901 and 1961 was 1.2% compound per annum. It however, does not include the period between 1941 to 1951 when there was practically no increase in population because of famine and war. However, between the period from 1951 to 1961

the growth of population there was about 20.9%. Therefore, for the same reasons as stated above for West Pakistan, it is hoped that the growth of population in East Pakistan during next forty years will not be more than 1.2% compound per annum, so that by 2000 AD the population in East Pakistan will not be more than 81.3 million.

National Income

4. The national income of Pakistan (2) at constant prices on the basis of average prices of 1950-1953 was $ 4750 millions in 1961, the per capita income per annum being $51. This income of an average Pakistani, however, does not give the true picture of the income of the majority population of the country. The distribution of population according to 1961 census was that in Pakistan 87% of the people were living in rural area, the rest in urban area. The occupation of the people living in rural area is primarily agriculture including fishery, forestry, etc. Table I shows that in 1961 the national income out of agriculture was 55% of the total national income. Therefore, about 87% of the population had income of the order of 55% of the total national income. This gives an annual per capita income to a person living in rural area of only $32.5 and to a person in the urban area of $170 per annum.

5. The Second Five Year Plan envisages an increase in the national income by 24%. After allowing increase in population, this will mean an increase in per capita income of 13%. If one thus estimates an increase of 13% in the per capita income of an average Pakistani during every five years of the next forty years, then by 2000 AD the per capita income will be about $136. But instead of keeping $136 as the per capita income on an average in 2000 AD, it is believed that this should be the per capita income of a person living in the rural area. This should not be very difficult to achieve because percentage of population in the rural by that time will decrease and it will increase in the urban area because of more expansion in the industrial sector. It is found from Table I that national income in the agriculture sector has been giving way to the manufacturing sector as it decreased from 61% in 1950 to 55% in 1961. It is estimated that by 2000 AD about 70% of the population will be living in rural area and 30% in urban area. And instead of having a difference of more than 5 times in the average income of a Pakistani living in rural area and the one living in urban area, it is hoped that this difference will decrease to 2½ times in 2000 AD, so that the average Pakistani living in urban area by that time will have a per capita income of $340. The per capita income of an average Pakistani in 2000 AD will therefore be about $200 compared to the per capita income in 1957 of an average U.S. American of $2350, of a Britisher as $790 and of a Japanese as $200.

6. The per capita consumption of power of a country, as shown by several authors (3)(4), bears a straight-line relationship with the per capita income of the country. It applies to all the developed countries and to most of the developing ones. Table 2 shows that there was an increase of 10 times in the per capita consumption of electricity in Pakistan from 1950 to 1960, but there was no increase in the per capita income. This was because there was very little progress in the largest sector of economy, i.e. agriculture, even though there was about 150% increase in industrial sector. On the whole whatever progress was achieved was eaten away by the increase in population. Therefore, instead of taking the per capita consumption of electricity as a measuring yardstick of the development of the country, we should take per capita income, since this would precisely determine the net benefit that an average Pakistani would derive. If we have

to have an average per capita income in 2000 AD of $200 according to the straight-line relationship, this would mean that an average Pakistani in 2000 AD should have a per capita consumption of electricity of about 1000 kwh. This was the consumption of an average Japanese in 1956. However, Japan's economic sectors are mostly energy-intensive, whereas in the case of Pakistan for a long time to come we could assume that our main sector of economy will be agriculture which is not energy-intensive. Therefore, taking a per capita consumption of electricity of 900 kwh in 2000 AD, the generating capacity that will be required to produce power sufficient to meet the demands of that time will be about 20,000 MW in West Pakistan. And taking a 800 kwh per capita consumption, in East Pakistan the generating capacity that would be required by that time will be about 17,400 MW.

Resources for Power Generation.

7. For geographic reasons, East and West Pakistan have been considered separately as far as their power resources are concerned.

8. East Pakistan

(a) East Pakistan consists of a flat deltaic region of two of the largest rivers of the world with very limited hydro-electric potential. The only major source of hydro-electric power from Karnafuli river of 80 MW has been tapped. The Province does not have any coal mine at present. The presence of good quality coal has been detected at a depth of 9000 feet in district Bogra. The depth of the deposit is such that its exploitation is un-economical at present. Peat has been found to exist in a large area of district Faridpur having a calorific value of 4,500 btu per pound. An attempt was made to burn this peat in boilers for power generation. After several years of research the project has been abandoned. No deposit of oil has been discovered so far. There are limited reserves of gas all having been dedicated to fertilizer or cement factories. The lately discovered deposit of 0.7 million million cft. is also being considered for another fertilizer factory.. Beyond these there are no indigeneous resources for power generation. Coal and furnace oil are imported at present to keep the power stations of East Pakistan going.

(b) It will, therefore, be seen that there are practically no indigeneous resources in East Pakistan to meet the growing demand of power of the next forty years, besides importing more and more coal and oil. We may be able some day to develop the coal mine at Bogra and the peat deposit in Faridpur. Whereas such developments may be possible in future, these deposits could not be regarded as resources as far as present long-term planning is concerned.

9. West Pakistan

(a) The theoretical hydro-electric potential of West Pakistan is estimated to be about 25,000 MW. It does not indicate what part of it will be economically and practically developed, for the reason that most of the potential is confined to inaccessible hilly regions of the North and North-West of the Province. The present known deposits of purified quality gas in West Pakistan are estimated to be 9 million million cft. Coal available in West Pakistan is of poor quality and low calcrific value. It is used mostly in cement and brick-kilns and not in boilers for power generation. Its estimated reserve is about 165 million tons. Oil produced in West Pakistan meets internal requirment by about 15% only. In any case, it is not used for electricity generation.

(b) It may be assumed that 50% of theoretical hydro-electric potential available in West Pakistan will be economically developed. This gives us a total generating capacity of about 12,500 MW. The deposit of gas that we

have at present may appear to be large compared to our present rate of consumption, but it should be mentioned that this is less than a year's consumption of gas in the United States (5) and less than 2 years consumption of coal in the United Kingdom. Our availability of gas should be viewed with respect to our long-term requirements in the following fields:

(i) Fertilizer: The total cropped area in West Pakistan is about 35 million acres and that in East Pakistan is about 26 million acres, the total being 61 million acres. The per acre production of Pakistan is one of the lowest in the world. Per acre production of wheat in Pakistan in 1955 was about 702 pounds against 1968 pounds in Egypt (6) and 1926 pounds in Japan and our per acre production of rice in 1955 was 1192 pounds against 3486 pounds in Egypt and 3889 pounds in Japan. There is no reason why we cannot increase our per acre production by intensification of agriculture to equal the production of Japan or Egypt today in the course of next forty years. Japan uses about 56 kg of fertilizer per acre against 2 kg in Pakistan. Since we have resources to produce fertilizer, we could use the same amount of fertilizer in Pakistan in 2000 AD as much as Japan uses today. One pound of nitrogenous fertilizer is understood to require about 25 cft. of gas. On this basis the total requirement of gas for the fertilizer factories to produce fertilizer for entire Pakistan, which would be established by 2000 AD will be about 5.7 million million cft.

(ii) Steel: 1 million million cft. of gas has been reserved for steel plants from the present known deposits (7). It is estimated that by 2000 AD this requirement will double as more and more steel mills are constructed.

(iii) Other Industries: It is estimated that other industries, such as petro-chemical, cement, textile, ceramic, engineering, and miscellaneous industries, will require by 2000 AD about 6.5 million million cft. of gas as against 2.2 million million cft. estimated to be consumed during the next forty years.

(iv) Therefore, to keep the industries which will be established by about 2000 AD going, the total requirement of gas will be about 14.2 million million cft. It can be safely assumed that about 50% of this will be consumed by the industries prior to 2000 AD, so that a total of 21.3 million million cft. of gas will be required exclusive of the requirement of power generation, whereas our present known deposit of purified quality gas is only 9 million million cft. What more deposits will be discovered during the next forty years is anybody's guess.

(c) Since gas could not be available for power generation the gap of 7500 MW in West Pakistan (difference between 20,000 MW and 12,500 MW) could be met only by importing more coal or oil. But gas is being used these days for power generation. This means that less gas will be available to us in future to meet our requirements in other fields.

10. In 1960 alone, for the whole of Pakistan, we had to import over 1.53 tons of coal and over 2.0 million tons of petroleum products spending over $66 millions in foreign exchange.

Future Trend in Conventional Power Costs.

11. Of necessity we should try to develop as much hydro-electric resources of Pakistan as they are practically and economically possible. There is, however, a limit to which this could be done. Table 3 shows a number of hydro-electric projects of Pakistan which have been completed

or are under construction. The capital cost of the projects per kw varies from $450 to $1280. Even though most of the hydro-electric projects are supposed to be multi-purpose, the returns from sectors other than power are insignificant. Therefore, the economic development of any hydro-electric project is of paramount importance. Nobody would probably start these days a project similar to the Karnafuli with so little return. The cost of production of power from these stations per kWh is not exactly known, but it varies from 10 to 22 mills. In fact the age of cheap electricity in Pakistan, it appears, is gone.

12. The oil price in Pakistan varies from 48 cents in Karachi to about 80 cents in East Pakistan per million btu. The FOB price of this oil in Persion Gulf is, as stated by the oil companies, $1.55 per barrel, which is of the order of 26 cents per million btu. So much difference between the available price of oil in Pakistan and the FOB price is due to poor transportation, poor port and handling facilities plus the taxes levied by the Government on oil.

13. There is a slab rate for the gas price in Pakistan depending on the consumption of the gas,-higher the consumption, lower the cost per unit. Oil and gas in Pakistan are controlled by the same group of companies. The gas price is usually aligned to the oil price prevailing in the country.

14. Table 4 gives the price indices (8) of furnace oil and coal which existed in Pakistan since 1955 and which shows that the prices have been going up. Gas price, however, from one source has been going down due to increase in the gas offtake through the pipe line. This sort of decrease is likely to continue till the pipeline reaches its maximum capacity after which it will increase again as and when more pipelines are constructed. Time and rate by which the price will increase will depend on a number of factors. It is only natural to think that the gas price will ultimately increase in Pakistan in course of time. This is however not likely to happen before 1970. As an example, the coal price in the United States in 1940 was $3.40 per ton. This gradually increased to $6.04 per ton in 1955 (5).

Prospects of Nuclear Power in Pakistan.

15 From what has been described above, it is found that there will be large gaps between the demand and the available source of power generation. To meet this gap either we import more conventional fuels at increasingly high cost or find some alternative source of power which could compete economically with power produced from these conventional sources. It is here we find that nuclear power can successfully compete with power from coal or oil or gas and can supplement in filling the gaps. If we have to import more coal and oil, there is no reason why we should not consider importing uranium, assuming that uranium will not be available in Pakistan, if power from uranium is competitive with power from coal,gas or oil. Against the rising trend in the prices of conventional fuels we know definitely that the cost of nuclear power will be going down in course of time because of improvement in its technology and gaining of experience from the plants which are being built around the world. Nuclear power does not only have the potential for economic competition with conventional power sources, but it also has potential for creating a scientific revolution in a developing country by introducing a new concept in the technological development of the country. Besides helping stabilise the conventional fuel prices, it will also give a stimulus to the scientific research on which

depends the industrial development of a country. In other words, the intangible benefits from a nuclear power programme in a developing country will be no less significant than its tangible benefits.

16. The Pakistan Atomic Energy Commission with the help of several consulting engineering firms, International Atomic Energy Agency as well as national atomic energy missions from West Germany, United Kingdom and Canada have made a number of studies about the economic feasibility of nuclear power in Pakistan. These studies revealed a number of things hitherto unknown in the power situation of the country and definitely would help Pakistan to develop national power programme on a rational and integrated basis.

17. The economics of nuclear power in Pakistan for plants of various sizes considered for a number of places are given in Table 5 with respect to conventional plants fired by gas or oil as the case may be. In East Pakistan the competitive source of nuclear power is oil, because gas is not available there for power generation In West Pakistan the source is gas, because it is at present sufficiently available. Coal is out of consideration because it is very costly and furthermore it is not used for power generation except in some power stations built long before. The economics study shows that nuclear power is competitive in Pakistan even at this stage of development of nuclear power technology even in the capacity range of 50 to 150 MW.

18. In view of the economics and the need for power it is believed that nuclear power will be a strong supplement to the conventional sources of power generation in Pakistan in course of time. In order to have such a technology within the country it is necessary that some beginning is made with a small nuclear power plant of 50 MW capacity so that our people learn the technology and soil their hands. It is difficult to have a big nuclear power programme right away because of our limited capability in trained manpower and of the level of scientific and industrial development of the country being not very high, even though our requirements may be urgent so as to suggest the adoption of such a big programme immediately.

T A B L E 1 - National Income.

(Price Average of 1950-1953) (Million Dollars)

Sector	1950		1955		1961	
	Income	%	Income	%	Income	%
Agriculture	2,200	61	2,450	59	2,630	55
Manufacturing	257	7	413	10	645	13.6
Others	1,163	32	1,307	31	1,475	31.4
Total	3,620	100	4,170	100	4,750	100

T A B L E 2 - Growth of Per Capita Electricity Consumption and per Capita Income Per Annum

	1950	1952	1954	1956	1958	1960
Consumption (Kwh)	2.61	4.53	7.49	11.63	17.24	27.6
Per Capita Income (Dollars)	49	49	50	48.5	50.3	50.

T A B L E 3- Capital Cost of some Hydro-Electric Projects in Pakistan.

Name of Station	Warsak	Gujranwala	Shadiwal	Karnafuli	Mangla
Capacity of Station(MW)	160	12	13.5	80	300
Capital Cost $/kW	450	610	625	1280	1180
Remarks	Completed	Completed	Completed	Completed	Under Construction

T A B L E 4- Change in Fuel Prices in Pakistan (Based on 1955 Prices)

Fuel	1955	1956	1957	1958	1959	1960	1961
Furnace Oil	100.00	121.4	122.6	123.1	107.0	105.8	105.8
Coal	100.00	139.5	191.1	217.9	213.6	160.9	171.9

T A B L E 5 - Comparative Cost Economics of Nuclear Power (9)(10)
(Based on 4 interest, 25 year loans)

Plant Capacity & Location (Plant Factor)	Nuclear Plant		Conventional Plant	
	Capital Cost ($ Millions)	Production Cost (Mills/kWh)	Capital Cost ($ Million)	Production Cost(Mills/kWh)
50 MW Plant in Dacca (80%)	26.5	9.53	16.7 (Oil Fired)	11.94
50 MW Plant in Khulna (80%)	26.5	9.53	16.7 (Oil Fired)	12.32
132 MW Plant in Karachi (85%)	42.2	6.30	29.0 (Gas Fired)	6.30
100 MW Plant in Karachi (80%)	35.6	7.14	24.4 (Gas Fired)	7.00
150 MW Plant in Chiniot (70%)	49.5	7.21	30.8 (Gas Fired)	7.87

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